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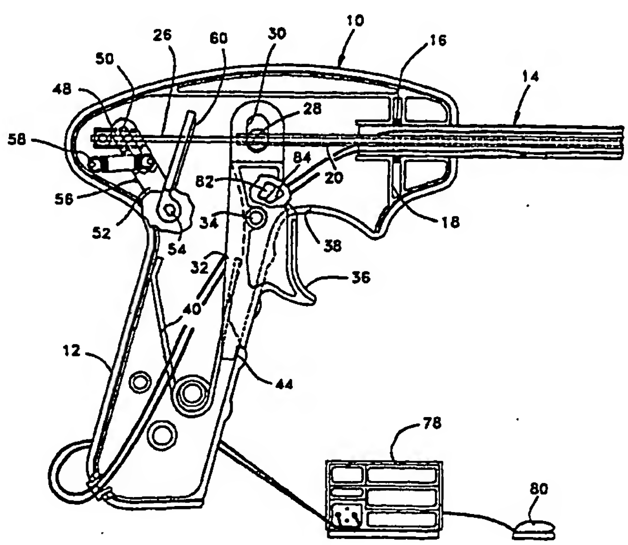
(54) Title: CUTTING AND COAGULATING FORCEPS



(57) Abstract

A cutting and coagulating forceps includes a housing (10) with a protruding barrel (14), a pair of electro-cautery jaws (22, 24) which are closed by camming contact with the mouth of the barrel (14) when the jaws are retracted, and an independently movable blade (62) which passes between the jaws. The jaws are opened by squeezing a trigger (36) and the blade is advanced by pressing a lever (60) with the thumb. Forward blade movement is limited by a stop (52) whose position is a function of the jaw position, so that the blade cannot strike the jaws, yet always can travel a distance just short of the jaw tips.

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Cutting and Coagulating Forceps

BACKGROUND OF THE INVENTION

Electrosurgery involves the application of electrical energy to tissues by an instrument having blades, jaws or the like which act as electrodes. Water is evaporated from tissues during electrosurgery, and with proper control of the intensity, frequency and duration of the applied energy, a surgeon can either coagulate or cut tissues.

A number of expired patents disclose electrocautery forceps having a pair of U-shaped jaws and a cutting wire which is advanced between the arms of the jaws to cut tissue clamped between them. More recently, U.S. Patent 5,258,006 disclosed an electrosurgical bipolar forceps having a pair of jaws which grasp and coagulate tissues, but not a cutting blade. The jaws are operated by a camming action produced when the jaws are moved along the tool by operating a lever on the tool body.

In the present invention, a purely mechanical cutting blade is employed, in conjunction with bipolar coagulating jaws. Both the blade and the jaws are independently movable along the axis of the tool. A high frequency voltage is applied across the opposed jaws after they have grasped a tube, ligament, or other tissue, to coagulate the tissue; once coagulated, the tissue is then mechanically cut by advancing the blade.

To enable the surgeon to cut completely through tissue clamped by the jaws, the blade must not travel beyond the coagulated area; otherwise, bleeding will occur. Ideally, the blade should have as much travel as possible within the jaws, but the blade must never actually contact the jaws, so a stop has been provided to limit forward blade motion. With this invention, the stop is movable, and affixed to the jaw actuating lever, so that regardless the location of the jaws, the blade is always stopped short of contact with the jaw tips. Thus, the blade stop moves to compensate for changes in jaw position.

SUMMARY OF THE INVENTION

An object of the invention is to prevent contact between a movable cutting blade and a pair of axially movable electro-surgical forceps jaws, while otherwise maximizing blade movement.

Another object of the invention is to enable a surgeon to move coagulating jaws and an associated cutting blade independently, without having to worry about interference between the blade and the jaws.

These and other objects are attained by a cutting and coagulating forceps including a handgrip-shaped housing with a protruding barrel, a pair of electrocautery jaws which are closed by interference with the mouth of the barrel when the jaws are retracted, and an independently sliding blade that passes between the jaws. The jaws are opened by squeezing a trigger, and the blade is advanced by pressing a lever with the thumb. Forward blade movement is limited by a stop whose position is a function of jaw position, so that the blade cannot strike the jaws.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Figure 1 is a view of a cutting and coagulating forceps, taken on a vertical plane substantially bisecting the device, showing the handle of the forceps and a rear portion of a barrel;

Figure 2 is a sectional view, taken from the top, of the front portion of the barrel and jaws protruding therefrom, showing the cutting blade in its retracted position,

Figure 3 is a side sectional view thereof, but with the blade advanced;

Figure 4 is a perspective view of the distal end of the forceps;

Figure 5 is an isometric view (with half of the housing removed) of a second embodiment of the invention, which includes means for rotating the jaws within the barrel;

Figure 6 is a side elevation, in partial section, of a third embodiment of the invention, wherein the axially sliding blade is replaced with a scissors-type blade;

Figures 7 - 9 show grasping, coagulating and cutting steps being performed in sequence with the instrument of Figure 6; and

Figures 10 and 11 are views of further alternative forms of the invention, each comprising a visual and/or audible coagulation indicator at the forward end of the instrument body.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A cutting and coagulating forceps embodying the invention includes a molded plastic housing 10 (Fig. 1) having a downwardly extending handle 12. A presently preferred material for the housing is produced by Monsanto under the trademark Lustran ABS. The housing is formed in substantially symmetrical halves joined on a vertical plane of symmetry "V". A tubular barrel 14 protrudes from the forward end of the housing, where it is retained between the halves by the combination of a ring 16 welded to the rear of the barrel and a corresponding annular groove 18 in the housing. While this barrel retention structure is presently preferred, other means might be employed.

The item running coaxially through the barrel 14 is a small metal tube 20. It is connected at its forward or distal end (Fig. 2) by a plug described below to a pair of jaws 22,24, and can move along the axis of the barrel to move the jaws. Within the tube is a slender rod 26 that is axially movable independently of the tube.

The rearward (proximal) end of the tube 20 (Fig. 1) is secured by set screws to a clevis 28 confined within vertically extending slots 30 at the upper end of spaced arms of an actuating lever 32. The lever is supported within the housing by a pin 34, whose ends are supported by the housing. The lever is concealed, except for a trigger portion 36 that extends through a slot 38 at the forward side of the handle.

When the trigger is squeezed toward the handle 12, it pivots the lever 32 in one direction (clockwise, when viewed from the right side of the tool as in Figure 1) moving the clevis and tube forward. A hairpin-type torsion spring 40 engaging the bottom of the lever biases the lever counterclockwise to a rest position defined by a stop 44 at the bottom of the lever. Clockwise movement of the lever is limited by interference between the a pin 82 on the lever and the slot 84 through which it protrudes. These parts are described further below.

The rear end of the slender rod 26 is affixed to a clevis 48, having set screws for adjustment, that rides in a slot 50 at the upper end of an idler arm 52 within the housing, supported on a transverse pivot shaft 54. The idler arm is normally drawn rearward, against a stop pin 56 in the housing, by a tension spring 58. The pivot shaft extends from both sides of the housing. Symmetrical thumb levers 60 are installed on the pivot shaft's ends, outside the housing. The pivot shaft's ends are provided with flats, keys or non-circular cross-sections to lock them to the thumb levers. Pressing either thumb lever forward pivots the shaft and the idler arm, driving the rod 26 forward. The presence of two thumb levers makes the device ambidextrous, but one could modify the device by omitting one of the levers omitted, if desired.

A cutting blade 62 (Figs. 2 - 4) is affixed to the distal end of the rod 26. The blade has a sharp, square cutting edge at its forward end, and wings 63 at its rearward end that have a close sliding fit within the barrel. The rear edge of the blade is rigidly affixed to the forward end of the slender rod by welding, for example.

The coagulating jaws 22,24 extend beyond the barrel mouth 70 a variable distance, depending on the trigger pressure and the thickness and nature of any tissues captured between the jaws. Maximum jaw stroke is about 0.635 cm. Each jaw, which may perform a coagulation function, is formed from a bight of slightly flattened stainless steel wire, so that it has a "U" shape when viewed vertically, as in Figure 3. The cutting blade is disposed within the .120 cm wide gaps between the

arms of each "U", with the width of the blade extending vertically. As can be seen in Figure 2, the blade has a sharp, square cutting edge facing forward, about even with the front end of the barrel when the blade is in its rest position (retracted). In this position, the blade is shielded by both the barrel and the jaw tips 65 to help prevent accidental cuts. The blade's maximum stroke is about 2.54 cm when the jaws are fully extended, less when the jaws are retracted.

The jaws have serrated mating surfaces 64, each comprising about ten teeth having a pitch of about .193 cm. The oblique faces of the teeth are at about 45° to the length of the jaws, and the teeth are arranged so that they mesh when the jaws close about a horizontal plane "H". One can see that the jaws converge at a slight angle toward the tip. The reason for the convergence is that, otherwise, the jaws would contact each other first at their proximal ends, closing the circuit and preventing current from reaching the tips.

The wires forming the jaws are bent so as to form what appears in Figures 2 and 4 as a bulge comprising proximal diverging segments 66 and distal converging segments 68. The bulge is larger than the barrel inner diameter, so that the diverging wire sections act as camming surfaces against the internally beveled mouth 70 of the barrel when the jaws are retracted.

The diverging segments 66 of the jaw wires are covered with a heat shrink electrical insulation material 72 which prevents electrical contact between the jaw wires and the barrel.

The proximal ends of the jaw wires are adhered or molded within a cylindrical plastic plug 74 which electrically insulates the wires from one another, as well as from the barrel. The plug is molded as well around the distal end of the actuating tube 20 for the jaws, and thus serves both as a mechanical connector and an electrical isolator. The presently preferred material for the plug is a crystalline co-polyester amide known as Vectra LCP; however, other materials may prove suitable. The plug has a close sliding fit within the barrel,

so that it functions as a dynamic seal to prevent loss of inflation gas from the surgical site. Within the plug, flexible conductors 76 are electrically connected to the proximal ends of the jaw wires. These conductors, shown diagrammatically, pass back through the barrel to the housing, down through the handle, and out through suitable connectors (not shown) to a power supply 78 controlled by a foot switch 80.

As mentioned, both the jaws and the blade can be independently reciprocated by the surgeon. Were the blade to be extended so far as to contact the looped end of the jaws, not only would be the blade edge be dulled, but also the blade would short the electrical path between the jaws. Thus, it is important to prevent overextension of the blade, and yet to maximize the stroke of the blade when the jaws are not retracted fully.

Forward blade motion is controlled by a stop whose position is a function of jaw extension. Overextension of the blade is prevented by providing a movable stop for the thumb lever. The stop is in the form of a pin 82 protruding from the actuating lever 32, through a slot 84 in the housing 10. The flattened rear surface on the pin is engaged by the forward side of the thumb lever just before the blade contacts the jaw tips, regardless of jaw position. Inasmuch as the pin is above the trigger pivot, it moves in the same direction as (but less rapidly than) the jaws. The further forward the jaws are advanced by squeezing the trigger, the further forward the stop is, allowing the blade to be advanced farther. Conversely, the range of blade movement is reduced substantially when the trigger is released, to protect the blade and prevent unwanted electrical contact.

In use, a tissue is grasped between the jaws by first squeezing the trigger to open the jaws, then advancing the jaws over the tissue and releasing the trigger. The torsion spring pulls the jaws back into the mouth of the barrel, whose camming action drives the jaws together, clamping the tissue. Depending on the tissue thickness, the jaws remain partially open a greater or lesser amount. The surgeon then may depress

the foot pedal 80, thereby impressing a high frequency voltage across the jaws, to coagulate the tissues. When the tissues have been sufficiently coagulated, the foot pedal is released, and the blade is then advanced by pressing one of the thumb levers forward. When the thumb lever is released, the tension spring retracts the blade, Finally, the tissue is released by squeezing the trigger.

Because the blade's forward stop position is automatically related to that of the jaws, it may be safely advanced until the stop pin is contacted, without fear of striking the jaws with the blade. The blade will thus remain sharp for at least the duration of the procedure, reducing costs and the need for spares.

Figure 5 depicts a second form of the invention wherein both the jaws and the cutting blade can be rotated within the barrel by manipulating a thumb wheel 100 which partially protrudes through slots 102 in the sides of the housing. The thumb wheel is mounted with a sliding fit on a non-circular hub 104. The hub shown has two flats to deliver torque from the thumb wheel to the small metal tube 20. An internal interlock 106 prevents the hub from sliding or rotating on the tube. A ball 128 is employed, in place of the clevis 28 described previously, to link the tube 20 to the lever 32, while permitting unlimited rotation of the tube about its axis. Similarly, a cylindrical member 108 is affixed to the rear of the slender rod 26, coaxial on the rod, so that the rod can rotate. The cylindrical member protrudes into windows on the sides of the clevis 148.

The thumb wheel has an undulating periphery, and its rear face has a number of dimples 110 at equal radii from the axis of the tube 20. The dimples act as detents in conjunction with leaf spring members 112 affixed to one side of the housing. The free ends of the leaf springs have semispherical protuberances on their forward faces (not visible), which seat in the dimples as they come into registration. This action gives the surgeon some tactile feedback.

The thumb wheel is prevented from moving forward out of

contact with the protuberances by the forward side of the slots through which the thumb wheel protrudes on either side. Thus, the slots act as thrust bearings for the thumb wheel, but not for the tube 20, since the hub is free to slide fore and aft through the thumb wheel.

Figures 6 - 9 illustrate a third form of the invention wherein the sliding blade is replaced by a single scissors-type pivoted blade 262.

Figures 6a and 6b depict the structure of the instrument, which includes a body 210 with a fixed handle 211 having an opening for receiving the surgeon's middle fingers, and two movable handles 236, 260 which may be manipulated independently with the index finger and thumb, respectively.

The forward handle 236 pivots on the body at pin 237; its upper end moves a pivot link 238 which pivots at 239. The upper end of the pivot link has an opening which receives a clevis 240 affixed by a set screw to a first link rod 220. The rear handle 260 is hinged to the body at 261, and receives a clevis 263 affixed by a set screw to the second link rod 226. Pulling the handle 236 rearward moves the link rod 220 rearward, while pushing the handle 260 forward moves the link rod 226 rearward.

The lower jaw 224 is fixed to the barrel, as by welding, while the upper jaw 222 is movable. An oblique slot 223 at the rear of the movable jaw, behind pivot pin 225, receives the 90° bent distal end of the link rod 220. As the rod moves fore and aft, it pivots the upper jaw.

The fixed jaw and the barrel nose 231 are formed in one piece, and the barrel is connected (see Fig. 6b) to one of the conductors from the power supply. The other conductor is electrically connected to the upper jaw, by the link rod 226, so that an electric potential can be applied across the jaws.

The scissors blade 262 is also mounted on the pivot pin 225, and also has an oblique slot. This slot receives the bent distal end 229 of the rod 226. Fore and aft movement of the rod causes the blade to pivot.

When actuated, the scissors blade 262 plunges into the gap

in the upper jaw, to cut tissue grasped between the jaws, as illustrated in Figures 7 - 9.

Figures 10 and 11 show fourth and fifth forms of the invention, characterized by the inclusion of visual and/or audible indicators for signalling doneness of the tissues being coagulated as electrical potential is impressed across the jaws.

In its preferred form, the visual indicator comprises a series of light emitting diodes 300 in a linear array simulating a bar graph. The LEDs are driven by a circuit which controls the number of segments which are eliminated as a function of the tissue impedance so that each LED has a progressively greater threshold current or voltage at which it activates. As tissues are coagulated, their impedance increases, reducing the coagulating current and/or increasing the electrical potential. The changing electrical characteristics of the tissues are thus graphically displayed.

The audible indicator, not illustrated, comprises a small speaker or a tone-generating chip having, for example, a piezoelectric element. The sound generator is driven by a circuit which controls the frequency of the sound as a function of sensed tissue impedance. Under the preferred scheme, the tone frequency increases with tissue impedance, giving the surgeon feedback without distracting his visual attention to the surgery.

It should be understood that the second, third and fourth embodiments of this invention are not mutually exclusive variations. The modifications may be applied cumulatively, so that, for example, one could have rotatable jaws, a scissors-type blade, and coagulation indication all in one tool.

CLAIMS

1. A cutting and coagulating forceps comprising

a housing,

a tubular barrel protruding from a forward end of the housing, the barrel having an open mouth at its distal end,

a pair of jaws partially protruding from the mouth of the barrel, and being movable in a direction parallel to the axis of the barrel,

means for moving the jaws parallel to the barrel axis so as to open and close the jaws,

a cutting blade disposed between the jaws, and being movable independently of the jaws, and

means for moving the cutting blade.

2. The invention of claim 1, characterized in that the jaws are electrically isolated from one another and from the cutting blade and the barrel, and further comprising

a power supply for generating an alternating coagulating electrical current and

conductors connecting said power supply to said jaws.

3. The invention of claim 2, characterized in that the jaws are electrically isolated from one another by a cylindrical plug molded around the ends of the jaws and secured to said jaw moving means.

4. The invention of claim 3, characterized in that the cylindrical plug has a close sliding fit within the barrel, to provide a dynamic seal for preventing loss of inflation gas from a surgical site.

5. The invention of claim 1, characterized in that the jaw moving means comprises

a lever pivotally mounted within the housing and having a trigger protruding from the housing whereby the lever can be pivoted in one direction by squeezing the trigger,

a return spring for pivoting the lever in the opposite direction, and

an elongated member connecting an upper end of the lever with said jaws.

6. The invention of claim 5, characterized in that the elongated member is a tube substantially coaxial within said barrel.

7. The invention of claim 6, characterized in that the blade moving means comprises

at least one thumb lever pivotally supported on the housing,

a rod affixed to said blade, and

means linking the thumb lever to the rod.

8. The invention of claim 7, characterized in that the rod passes through said tube.

9. The invention of claim 7, characterized in that the linking means comprises a pivot shaft supporting said thumb lever, an arm within the housing connected to the pivot shaft, and a clevis connecting one end of the rod to the arm.

10. The invention of claim 9 comprising two said thumb levers, each being connected to a respective end of said pivot shaft.

11. The invention of claim 7, further comprising a return spring connected to said arm, for drawing said rod rearward.

12. The invention of claim 1, characterized in that the blade is movable fore and aft along the axis of the barrel, and the forceps includes a movable stop connected to the jaw moving means for limiting forward movement of the blade, so that it cannot strike the jaws.

13. The invention of claim 12, characterized in that the movable stop is affixed to said lever and moves in the same direction as the jaws when the trigger is squeezed.

14. The invention of claim 13, characterized in that the movable stop protrudes through a slot in the housing into the path of the thumb lever.

15. The invention of claim 1, characterized in that each jaw has a toothed surface facing the opposite jaw.

16. The invention of claim 15, characterized in that each toothed surface comprises a series of teeth which mesh with those of the opposite jaw when the jaws are closed.

17. The invention of claim 16, characterized in that the jaws converge at a slight angle toward their tips, so that they meet first at their tips as they close.

18. The invention of claim 16, characterized in that the teeth have a pitch of about .193 cm.

19. The invention of claim 16, characterized in that the teeth are substantially triangular in cross-section, having surfaces disposed at about 45° to the length of the jaws.

20. The invention of claim 1, characterized in that the jaws and the blade can rotate about the barrel axis, and further comprising a thumb wheel partially protruding from the housing and connected to said jaws, whereby the jaws can be angularly aligned with tissues to be coagulated.

21. The invention of claim 20, characterized in that the thumb wheel has a plurality of depressions formed in its rearward surface, and further comprising at least one leaf spring having a protuberance for engaging within any one of said depressions to provide a tactile indication of jaw rotation.

22. The invention of claim 1, characterized in that the barrel has a mouth at its distal end, and the jaws have diverging segments whose outboard surfaces bear against the mouth and cam the jaws closed as the jaws are withdrawn toward the mouth.

23. The invention of claim 1, characterized in that the blade is normally withdrawn entirely within the barrel, to protect against accidental cuts.

24. A cutting and coagulating forceps comprising

a housing,

a tubular barrel protruding from a forward end of the housing, the barrel having an open mouth at its distal end,

a pair of jaws partially protruding from the mouth of the barrel,

means for manually opening and closing the jaws,

a cutting blade disposed between the jaws, and being movable independently of the jaws,

means for moving the cutting blade,

means for impressing an electric potential across said jaws, so that they can be used to coagulate tissues grasped between the jaws, and

means for providing a continuous indication of the electric impedance of said tissues as they are being coagulated.

25. The invention of claim 24, characterized in that said indication means produces an audible signal.

26. The invention of claim 25, characterized in that said audible signal is a tone whose frequency increases as tissue impedance increases.

27. The invention of claim 24, characterized in that said indication means produces a visual signal.

28. The invention of claim 27, characterized in that said indication means comprises a series of light emitting diodes which light progressively as tissue impedance increases.

29. A cutting and coagulating forceps comprising

a housing,

a tubular barrel protruding from a forward end of the housing, the barrel having an open mouth at its distal end,

a pair of jaws extending from the mouth of the barrel,

means for impressing an electrical potential across the jaws to coagulate tissues grasped between the jaws,

means for manually opening and closing the jaws,

a pivotable cutting blade, movable independently of the jaws, for cutting tissues grasped by the jaws, and

means for manually moving the cutting blade independently of the jaws.

30. The invention of claim 29, characterized in that one of said jaws is fixed to the barrel and the other jaw is movable.

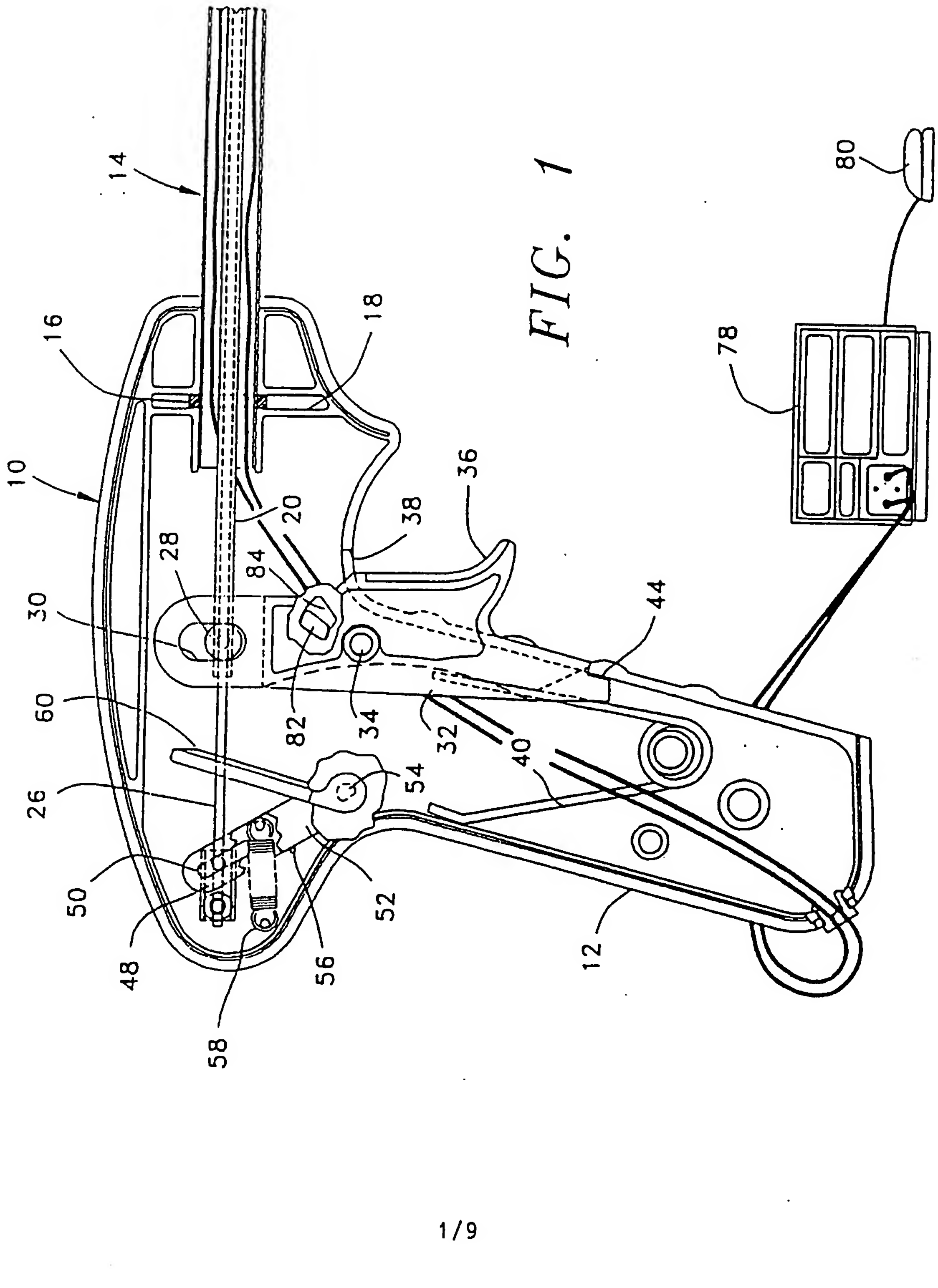

FIG. 1

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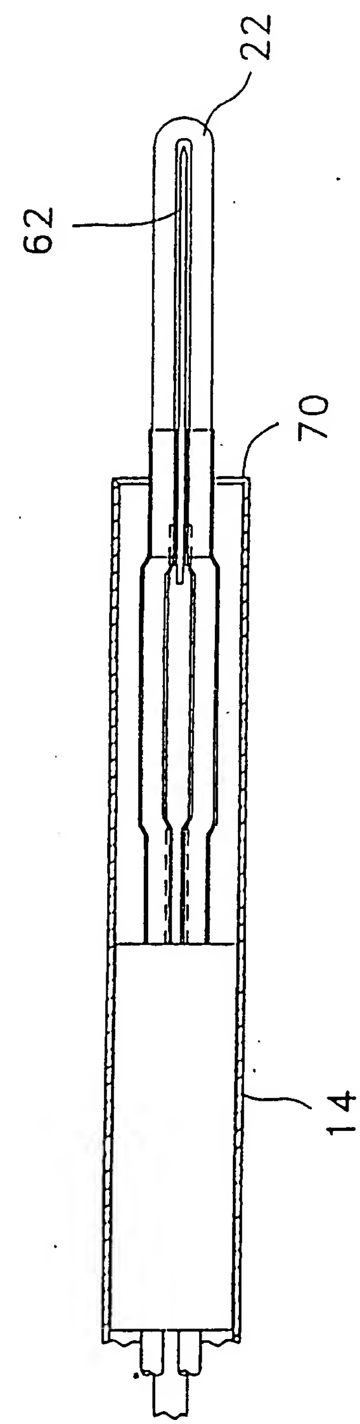

FIG. 3

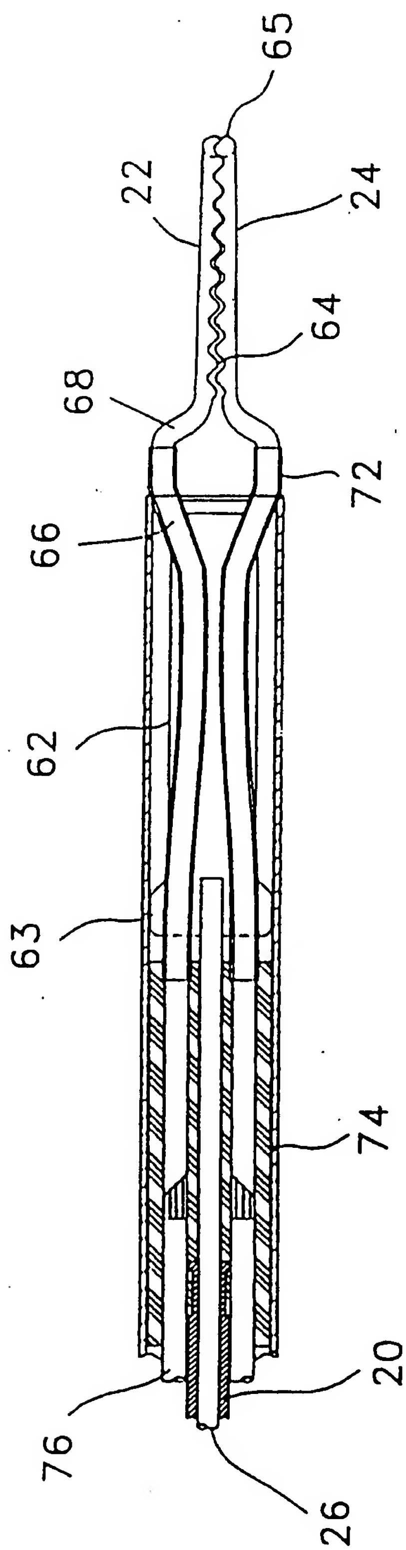

FIG. 2

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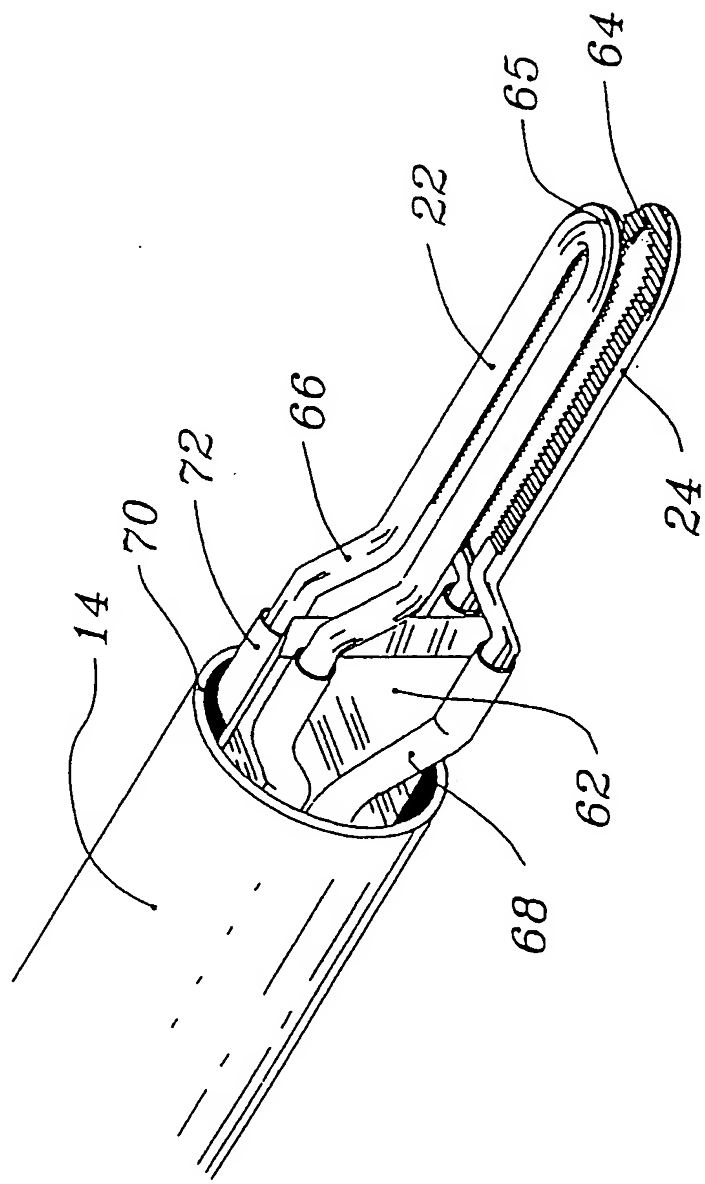

FIG. 4

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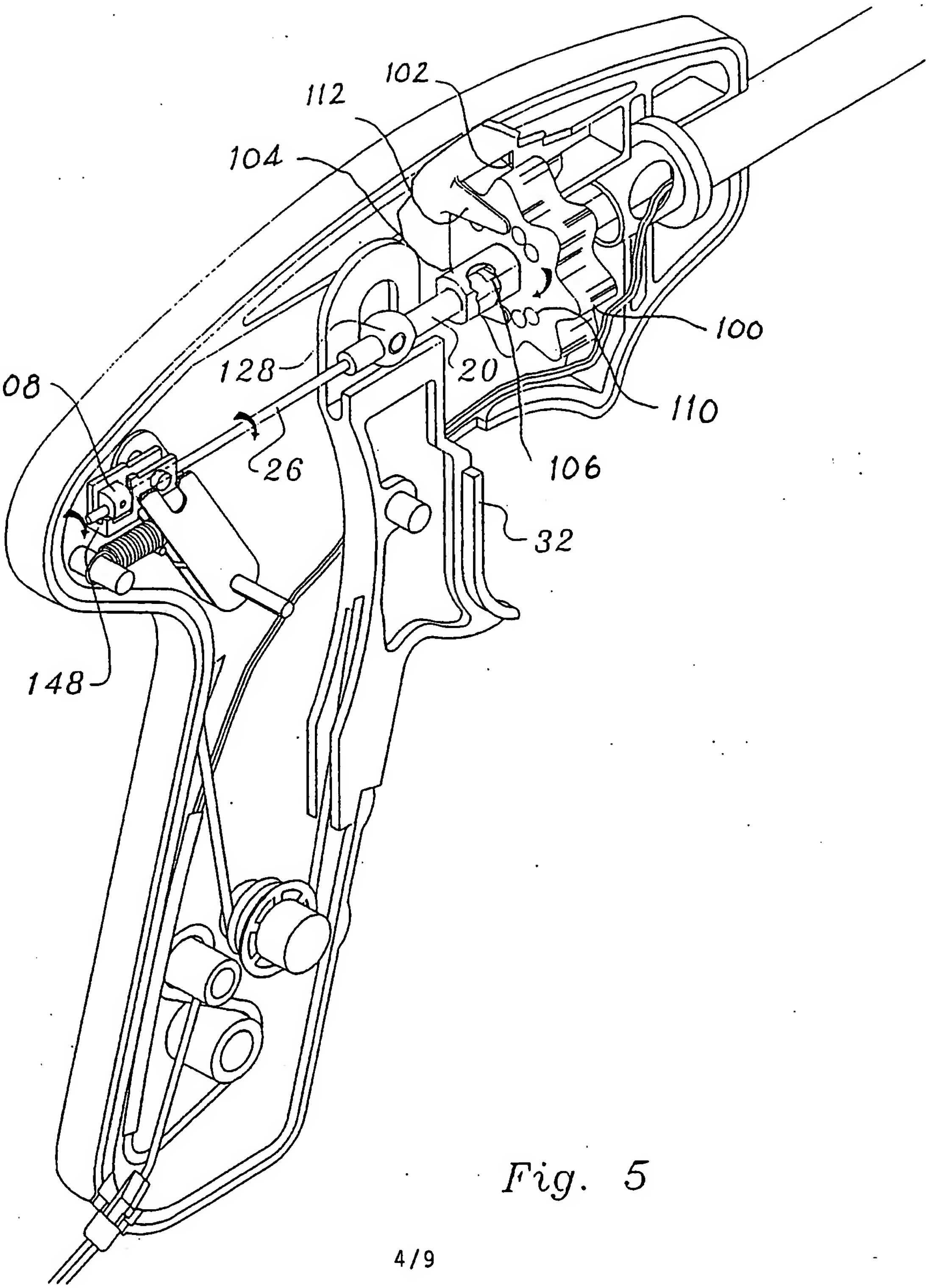

Fig. 5

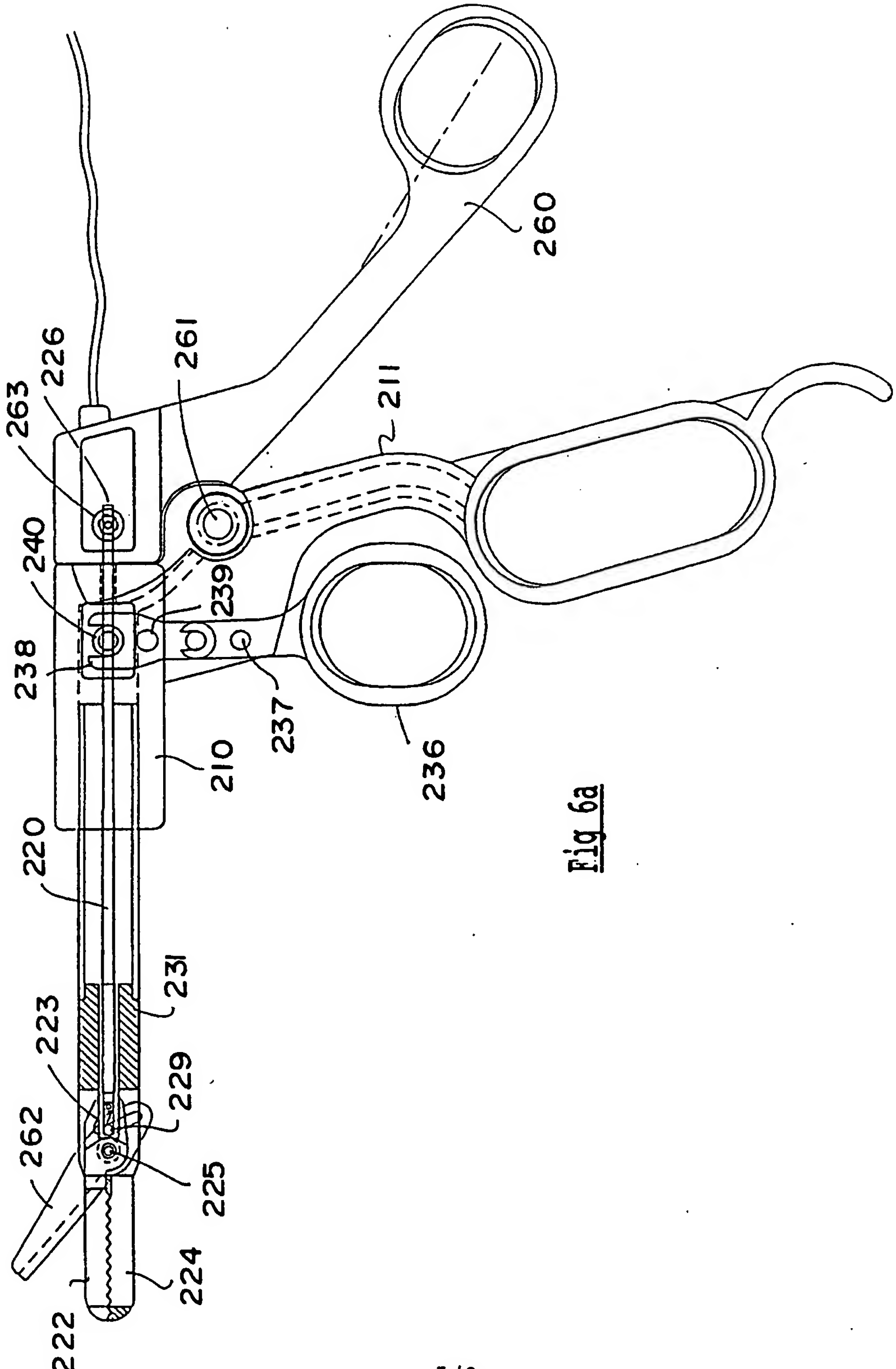

Fig 6a

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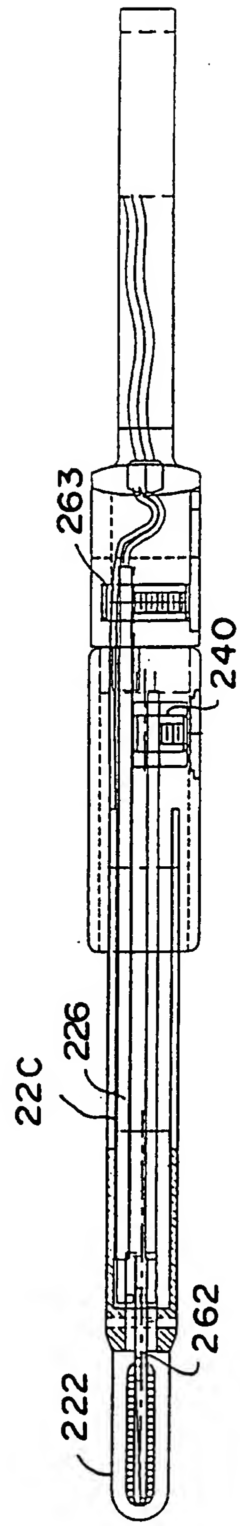

Fig 6b

SUBSTITUTE SHEET (RULE 26)

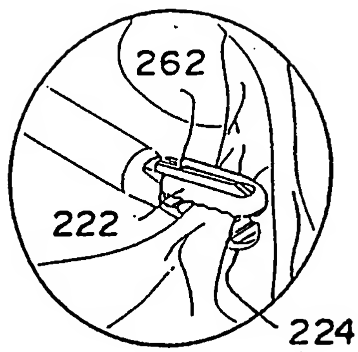

Fig. 7

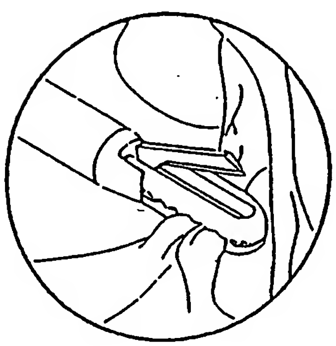

Fig. 8

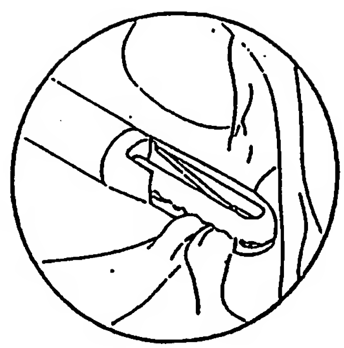

Fig. 9

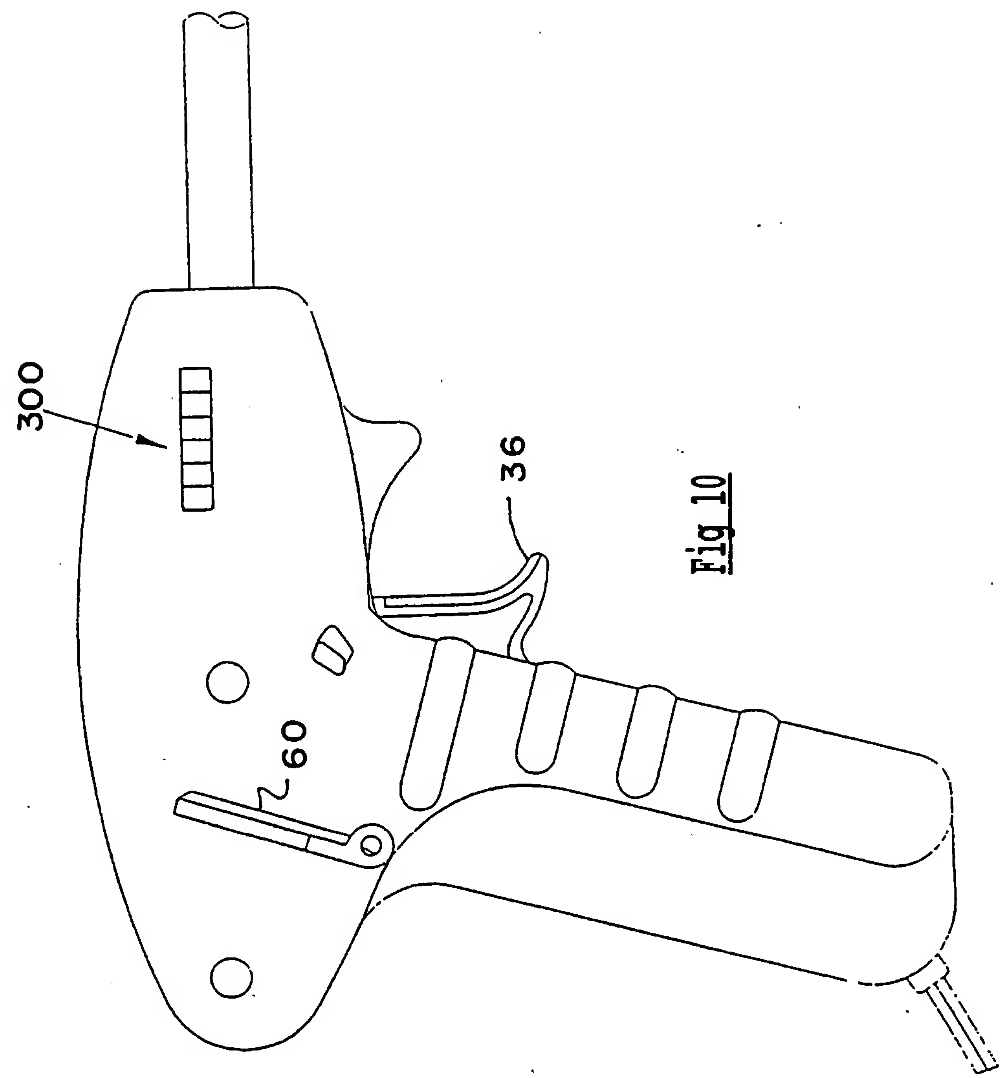

Fig 10

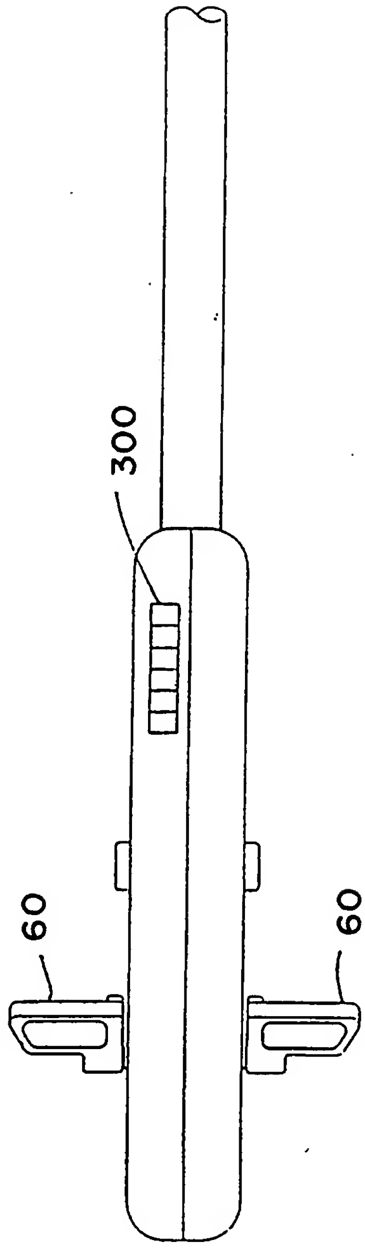

Fig 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/13292

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61B 17/36
US CL :606/52
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 606/41, 42, 45-52, 205-208

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,190,541, (ABELE ET AL.), 02 March 1993. See whole document, and figures	1, 2, 5 --- 3, 4
Y	US, A, 2,068,721, (F. C. WAPPLER ET AL.), 26 January 1937. See whole document, and figures	1, 2, 5, 6, 15-30
Y	US, A, 3,920,021, (HILTEBRANDT), 18 November 1975. See whole document, and figures	1, 2, 5, 6, 15-30
Y	US, A, 5,254,117, (RIGBY ET AL.), 19 October 1993. See Fig. 1, and element (20) in the specification.	20, 21

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/13292

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,167,658, (ENSSLIN), 01 December 1992. See Abstract, and whole document.	24-28